Mosquitoes are slender bodied, long-legged insects and are easily recognized by their long proboscis and the presence of scales on most parts of the body. They belong to the Culicidae family of order Diptera and found throughout the world except Antarctica. The number of formally recognized mosquito species is 3,490 from World (Ward, 1992; Harbach and Howard, 2007). But the actual number is expected to be much more (2-3 times) than this.

Several species of the mosquitoes are the prime vectors responsible for the spread of serious human diseases such as malaria, Japanese encephalitis, dengue, chikungunya, lymphatic filariasis, epidemic poly-arthritis as well as yellow fever. However, among all the diseases, malaria is considered as the worst enemy of a malarious country because it irreversibly affects the public health and overall development (Sarkar and Vijay Veer, 2010). Transmission of dangerous diseases by mosquitoes was known in the medical history for more than a century. Attempts have been made to eradicate or control mosquitoes in order to eradicate or control concerned diseases. Even then, much success has not been obtained and mosquitoes are still flourishing as a major threat to human beings and live stock. However, people of less privileged populations, throughout the tropical and subtropical regions of the world, are at greater risk and every year mosquito transmit disease to more than 700 million people (Ahad, 2010). Occasionally extremely large numbers of mosquitoes are produced and in addition to human beings, they can cause the deaths of domestic animals also through mass biting of mosquitoes resulting in heavy blood loss and also due to anaphylactic shock of painful mosquito bites. Mosquito bites are the cause annoyance and trouble including discomfort, itching, restlessness, loss
of sleep and nervous irritation in people, pets and domestic animals that suffer from their attacks. Mosquito borne diseases have many economical and sociological adverse effects on human and domestic animal populations (WHO, 2013).

Among all insect-borne diseases malaria remains one of the major deadly diseases in many countries of Africa, Asia and Latin America. There are about 70 species of *Anopheles* mosquitoes are known to be capable of transmitting malaria. Four species of malaria parasites, infect humans, viz. *Plasmodium vivax, P. falciparum, P. malariae and P. oval*, cause malaria and are transmitted through mosquitoes. At least one of these species was detected in the blood sample of nearly 300 million people. Malaria is transferred to humans only via mosquitoes and 300 - 500 million fresh people are affected by malaria per year, out of them 1.5 to 2.7 million people are killed; every 12th second one child dies due to malaria (WHO, 1999; Patel *et al.*, 2012). Currently about 2,100 million people live under the threat of malaria in 103 countries, and about 445 million of these are in areas where facilities of control measures are not available.

Elephantiasis disease is caused by three nematode species belonging to the family Onchocercide. These are *Wuchereria bancrofti, Brugia malayi* and *Brugia timor* and they are transmitted by *Culex quinquefasciatus* or by *An. barbirostris*. There are about 751 million people at risk of lymphatic filariasis in 76 countries (Service, 1993). Yellow fever is yet one more important mosquito-borne diseases spread by *Aedes aegypti*. Yellow fever is caused by viruses found in the salivary glands of mosquitoes when they take a blood meal from infected man or animal, 12-15 days before.
Dengue Fever and Dengue Hemorrhagic Fever (DHF) caused by an Arbovirus, are the common and emerging mosquito-borne viral diseases that affect a wide range of people in the world (Wiwanitkit, 2014). It is caused due to the bite of infected *Aedes* mosquitoes of one of the following species *Ae. aegypti, Ae. albopictus, Ae. scutellaris* and *Ae. polynesiensis*. *Ae. aegypti* mosquito is a cosmopolitan and anthrotropic vector that transmits dengue, dengue hemorrhagic fever (DHF) and chikungunya in India and yellow fever in Africa and South America (Clements, 1992). *Ae. aegypti* is a small (approx 5mm in size), a dark mosquito with white markings and banded legs, hence it is known as tiger mosquito. White marking over the thorax is distinguishing feature of *Ae. aegypti*.

*Ae. aegypti* mosquito lives in urban habitats and breeds mostly in artificial and man-made containers (Julian, 2009; WHO, 2012) and it is a daytime feeder; its peak biting period is early in the morning and before dusk in the evening (WHO, 2012). *Ae. aegypti* female mosquitoes bites multiple people during each feeding cycle. Since its first description of the Philippines in 1953, dengue haemorrhagic fever has become one of the leading causes of childhood illness and mortality in Southeast Asia too and it has been reported increasingly in the Americans over the past decade (Clements, 1992). While dengue is a global concern, with a steady increase in the number of countries reporting the disease, currently close to 75% of the global population exposed to dengue are in the Asia-Pacific region. According to World Health Organization (WHO, 2013) over 50 – 100 million people with severe dengue require hospitalization each year, a large proportion of whom are children, about 2.5% of the affected children die.
Dengue is prevalent in more than 100 countries and it threatens the health of approximately 2.5 billion people (Norashiqin, 2008; Gu et al., 2009) and around eighty million people are infected annually at an attacking rate of 4% worldwide (Monath, 1994). In India, the first epidemic of clinical dengue-like illness was recorded in Chennai in 1780 and the first virologically proved epidemic of dengue fever (DF) occurred in Kolkata and Eastern Coast of India in 1963-1964 (Gupta et al., 2012). In India 7-16 thousand cases of dengue are reported annually.

Insect pests exert a significant amount of destructive influence on human beings; they damage our food and non-food crops, have nuisance value and act as vectors for human animal diseases. Therefore, several measures of pest control and management have been discovered and implemented. Chemical control using synthetic organic insecticides is the major strategy for pest management including mosquitoes. DDT, extensively used for mosquito control is completely based on synthetic organic insecticides. However, the existential use of synthetic insecticide has resulted in environmental hazards and also in the development of physiological resistance in major vector species. Hence, emphasis is now given to a variety of alternative control methods.

The deadly diseases carried by insect and mosquito vectors and the annoyance caused by them encouraged the discovery of control measures including methods of personal protection. Mosquito control programs are essential to prevent spreading of mosquito borne diseases. Mosquito repellents are used as a personal protection which can
provide practical and economical means of preventing mosquito-borne diseases (Revay et al., 2012).

Every year millions of people are affected by mosquito born diseases worldwide and the use of insect repellent to the skin is a common personal protection (Barnard and Xue, 2004). In 485 BC, Herodotus (Greek Historian) wrote that he observed Egyptian fishermen using castor-oil on their skin and they used the same oil in lamps to keep mosquitoes away at night (Charlwood, 2003). Just around the 4th Century, ancient Romans repelled mosquitoes by rubbing a combination of vinegar, manna and plant oil on their bodies. However, they (Romans) also burned herbs including black cumin, bay, galbanum and oregano to repel insects (Moore and Debboun, 2006).

A mosquito repellent is a substance applied to skin, clothing, or any other surfaces to discourage them from landing on the treated surface. In general, mosquito repellents are not very specific in their action, they may also repel other insects or even the arthropods. The traditional definition describes repellent as a thing that causes oriented movement away from a source, essentially the opposite of an attractant which is a thing that causes oriented movement towards a source (Dethier et al., 1960). Repellents express themselves through two modes of action; contact repelling action, the arthropod vector has to come contact with the substance, where’s for vapour or volatile action, the substance is to be detected in air (Jcobson and Crosby, 1971; White, 2006).
In general, the purpose of repellent is to discourage insect to feed upon its food that is also useful for us or the feed upon human or animal host. The feed deterrenency is often confused with repellency. The deterrenency or antifeedancy involves contact (chemical) action; the insect comes and land on food, probes the food with the help of taste receptors which may be located on antennae, forelegs and or mouth parts. Like volatile chemical-based attractancy, the repellency also involves vapour or volatile action, the insect detects the air-borne smell with the help of chemoreceptors located on antennae and then responds accordingly.

The use of repellents for the protection from biting arthropods has a long history that predates humanity. Many animals utilize substances for repelling predators and parasites. For example, capuchin monkeys anoint their pelage with odorous materials that repel ecto-parasites. They rub their fur with carpenter ants (*Camponotus* sp.) so that ant's defensive semiochemical, formic acid is spread over the fur, which in turn repels the tick *Amblyomma cajennense* (Falotico *et al*., 2007). At the time of maximum mosquito activity, the capuchin monkey, *Cebus olivaceus*, rubs its fur with the millipede *Orthoporus dorsovittatus* (Order: Spirostreptida), anointing itself with the millipede’s insect-repelling benzoquinone secretions (Valderrama *et al*., 2000; Weldon *et al*., 2003). The white faced capuchin, *Cebus capucinus*, is particularly fascinating in that fur rubbing can either be a solitary event, or a communal behaviour in which group members synchronously anoint their fur with plants that have repellent properties (Meunier *et al*., 2008). Other animals that anoint their pelage or plumage for protection from ectoparasites include the black-handed spider monkey, *Ateles geoffroyi*, and owl
monkeys, *Aotus* spp. (Meunier *et al.*, 2008) and various species of birds (Falotico *et al.*, 2007).

The burning of various plants or plant oils and other materials to produce smoke as a repellent is the oldest method recorded for repelling nuisance mosquitoes by humans. The burning of various plants, fish, bones, and dung to repel mosquitoes has been described in Geoponika (10th century) and the ancient Sanskrit *Yoga Ratnakara* (17th century) (Owen, 1805; Moore and Debboun, 2006).

Essential oils are defined as natural volatile substances found in a variety of odoriferous plants. They are in the form of concentrated hydrophobic liquid containing volatile aroma compounds obtained from different parts of plants (Zhu *et al.*, 2001). Essential oils are generally extracted by distillation method. Different methods of distillation can be used for the purpose. Hydro distillation, steam distillation and solvent extraction are the commonly used techniques. A variety of biological activities including behavioural responses have been recorded towards such essential oils in different animals human and plants. The term “biological response” comprises all activities that these volatile compounds or their mixtures exert on humans, animals, and other plants (Baser and Buchbauer, 2010). In fact the essential oils are secondary plant metabolite and their major active constituents are monoterpenoids, sesquiterpenoids, benzenoids, phenylpropanoids etc. The composition of essential oils is highly diversified across different plant species and is directly affected by climatic and soil conditions. The properties and proportion of monoterpenoides depend on temperature, circadian rhythm
and plant stages (Clark et al., 1981). However, they are produced in aromatic species of higher plants belonging mostly to a few families, including the Myrtaceae, Lamiaceae, and Asteraceae. The accumulation and synthesis of essential oils are associated with complex secretory structures such as glandular trichomes (Lamiaceae), secretive (Myrtaceae, Rutaceae) and resin ducts (Asteraceae, Apiaceae) (Rodriguez et al., 1984). Depending on different species essential oils are stored in various parts of plants organs such as flowers, leaves, wood, roots, fruits, rhizomes and seeds. They are used in perfumes, cosmetics, soaps, for flavoring foods, drinks, and for adding scents to incense, household cleaning products and various essential oils have been used in medical formulations.

Main oil producing plants are represented in more than thirty families of plants, comprising some ninety species. The majority of spices (cardamom, clove, nutmeg, ginger etc.) originate from tropical countries. Conversely the majority of herbs (bay, cumin, dill, marjoram, fennel, lavender, rosemary, thyme, etc.) grow in temperate climates. The same plant grown in different regions and under different conditions can produce essential oils of widely diverse characteristics, which are known as "chemotypes". Common thyme (Thymus vulgaris), for example produces several chemotypes depending on the conditions of its growth and dominant constituent, notably the citral or linalool types, and the thymol or carvacrol type. It is therefore important not only to know the botanical name of the plant from which an oil has been produced, but also its place of origin and main constituents which are concerned to define its qualities (Lawless, 1992).
Essential oils are extracted from almost every conceivable plant part, such as flowers like rose and chamomile, leaves as peppermint and rosemary, fruits of orange and lemon, seeds as in coriander and fennel, grasses like lemongrass and ginger grass, roots and rhizomes as ginger, wood of cedar wood and sandalwood, bark like in cinnamon, gum as in frankincense (Tisserand, 1990). There are also essential oil from bulbs like garlic, dried flower buds like clove, and from stems or twig like clove stem. Usually they are liquid but can also be solid or semisolid, according to temperature such as rose. The majority of essential oils are clear or pale yellow in color, although a few are deeply colored like German chamomile (blue). They are damaged by the effects of light, heat, air and moisture, and should always be kept in a cool environment, in tightly Stoppard dark glass bottles. Essential oils are dissolved in pure alcohol, fats and are not soluble in water (Tisserand, 1990).

Chemicals play an important role in influencing vital activities (search for food, opposite sex, an oviposition site or medium) of insects. It can be said that host seeking mosquitoes are attracted to human body odours, which have different substrates such as urine, feces, carbon dioxide and lactic acid (Stib et al., 2001; Rebollar-Tellez, 2005; Gibson et al., 1999). Host-seeking mosquitoes detect host-derived chemicals with the help of two major sensory organs. The maxillary pulps detect the level of CO₂ and olfactory receptors of antennae detect host-related odours (Takken, 1991; Dekker et al., 2005; Zwiebel and Taken, 2004).
The insect repellents play important role as a barrier for protection against blood sucking insects, because they can be used anywhere, anytime and applied in various forms such as directly to the skin, to clothing or other fabrics and other surfaces (Fradin, 1998). There are two kinds of repellents: synthetic and natural (plant-derived) repellents.

At the time of Second Ward War only four repellents were known such as Citronella oil, Dimethylphthalate, Indalone and Rutgers (Peterson and Coats, 2001). A large number of potential mosquito repellent compounds were screened by US Army and in 1953 \( N, N\)-diethyl-3-methylbenzamide also known as \( N, N\)-diethyl-m-toluamide (DEET), the “gold standard” repellent of modern days was discovered (Kweka et al., 2012) The mode of action of DEET has been a topic of controversy for some time. DEET may cause adverse toxic effects, especially in young children, pregnant and lactating women (Koren et al., 2003). The synthetic repellents have disadvantages including strong odours, skin irritation, possible health effects, resistance development and environmental hazards.

Due to these adverse effects, attempts are made to find safe and eco-friendly repellents derived from plant materials. In the last few years with the increase of public concern on the safety of many chemical products that were used previously as insecticides and repellents, several institutes and researchers were directed to the development of natural active ingredients especially from plant sources because they are believed to be safe to human use and are easily biodegradable (Sharma et al., 1993-1994).
The essential oils have been used by entomologist as mosquito larvicides and for repelling insect pests including haematophagous insects. Most commonly used essential oils as repellent are citronella, geranium, cedar, peppermint, rosemary, soybean, and eucalyptus (Arnason et al., 2011).

Vectors play an important role in transmission of deadly diseases. So insect repellents may be used to prevent and control the outbreak of insect borne diseases. Essential oils are composed of volatile components having minor and major constituents with pleasant fragrance to human beings. But this aroma may not be pleasant (attractive) to mosquitoes and has repelling action. In comparison of synthetic repellents, botanical repellents generally perform significantly less well, they have shorter protection time and hence they need frequent re-application. These drawbacks can be resolved by further investigations on repellency of essential oils. Thus there is a need to develop eco-friendly, safe, cost effective repellant for vector control. The proposed work is expected to provide us the information about repellency of various essential oils against mosquito.

In the study an attempt has been made to study repellency of 23 essential oils against Ae. aegypti mosquitoes in laboratory condition with the help of standard bioassay methods. In the study we have determined the repellent effect or effective dose of essential oils and also investigated the overtime repellency of essential oils with the help of K & D module (Klun and Debboun, 2000). K & D module is easy to use in laboratory
condition also useful for identification of repellent efficacy of various doses over single species and single doses over various species.

Essential oils are composition of volatile components having minor constituents contain pleasant fragrance. Using an Olfactometer bioassay is quick and effective way to evaluate the behavioural responses of mosquitoes toward volatile stimuli of essential oil and also analyse essential oil for antennal response with the help of gas chromatography-electroantennogram detection (GC-EAD) and GC-EAD technique is useful for identification of particular volatile components which are responsible for excitation of sensory receptor neurons in antennae. Gas Chromatography/Mass Spectrometry (GC/MS) are standard equipment used to analyze major chemical components present in 23 essential oil obtained from Fragrance and Flavour Development Center, Kannuj, U.P. India.

A better understanding of 23 essential oils repellent efficacy and finding effective repellent constituent present in essential oil is important for guiding research to develop newer, safe repellent for controlling transmission of mosquito borne diseases and also for new strategy or formulation against vector born insects.